Session 8 Overview

Biomedical Devices

Chair: Roland Thewes, *Qimonda, Neubiberg, Germany*

Associate Chair: Dennis Polla, *DARPA, Arlington, VA*

CMOS ICs for biomedical applications have attracted a great deal of interest in recent years. The signal processing and computing capabilities available in small devices with low power consumption open up new horizons in biomedical interfacing. While some of these CMOS-based techniques are still in their infancy, others have already provided commercial solutions. In this session, recent advances are presented concerning prosthetic and implantable devices, in-vitro neural recording, and amplifiers for bio-electrical signals, magnetism-based cell imaging and bio-molecule detection techniques.

Paper 8.1, from sci-worx and IIP Technologies, reports on a retinal implant with a total of 232 channels, where 116 of these can be independently operated – the highest number of channels reported to date. Moreover, special emphasis is put on programmability, testability and safety.

The authors of Paper 8.2, from KAIST, present a hearing aid chip custom tailored to the individual's auditory canal. Key innovations in this chip include the implementation of a pre-fitting verification algorithm that implements both coarse and fine amplifier gain adjustments. A significant amount of electronics was integrated with the hearing aid to implement this new algorithm.

Paper 8.3, from UC Santa Cruz, reports on the use of a PSK receiver using bandpass sampling for potential neural implant stimulation applications. This approach eliminates the need for phase-locked loops in recovery circuits and implements an attractive approach for realizing transcutaneous inductively-coupled telemetry to support high-data-rate neural implants such as 1000-electrode arrays to be used in future retinal prosthesis systems.

CMOS chips are highlighted for in-vitro recording and stimulation of neural tissue. Paper 8.4, from ETH Zurich, NewLogic and Miromico, describes a CMOS microelectrode array with 126 channels. By selecting target sites within an array of 11k electrodes by means of a switching matrix, a spatial resolution of 18μm is achieved, allowing one to focus the available recording and stimulation capability on regions of interest within neural tissue slices. An alternate neural interface in Paper 8.5, from U Toronto and Toronto Western Hospital, uses a 2D CMOS chip with 256 channels combined with noble metal needles to form a 3D interfacing system. High recording accuracy and data compression are obtained by using a SC-based delta read-out approach.

Two amplifiers are presented for bio-electrical signal detection and processing. Paper 8.6, from Medtronic, describe an ultra low-power, low-noise chopper-stabilized instrumentation amplifier for "deep brain" human implants. A current-sensitive amplifier is presented in Paper 8.7 by Politecnico di Milano uses a specifically developed design technique to provide ultra-high resistance active resistors up to 300GΩ. These are operated in the feedback path of a transimpedance amplifier interfacing with extremely low signal currents.

The authors of Paper 8.8, from National Tsing Hua U report on their work integrating MEMS gradient- and RF-coils with CMOS circuitry for a new compact approach to 3D cellular imaging. Miniaturization and integration methods are described for future high-resolution magnetic resonance imaging (MRI) microsystems.

Finally, Paper 8.9, from Stanford and Stanford Genome Technology Center, expounds on the circuit design issues addressed by the first CMOS-based magnetoresistive DNA microarray. Based on a 0.25μm BiCMOS technology, the sensor-site circuitry provides input-referred noise levels below $55nV/\sqrt{Hz}$. Drifts induced by chemical and biochemical reactions are removed using AC techniques; readout is realized by means of combined frequency-division and time-division multiplexing.

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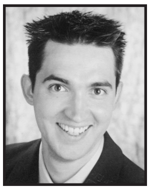

8.1 A 232-Channel Visual Prosthesis ASIC with Production-Compliant Safety and Testability **8:30 AM**

M. Ortmanns, sci-worx, Hannover, Germany, Now with Albert-Ludwigs-University, Freiburg, Germany

A retina stimulator has been realized in 0.35μm HVCMOS. The $22mm^2$ ASIC features wireless operation, custom ESD protection and programmable reference tuning. It has 232 channels combined with production-compliant testability and safety, and output swing as high as ±10V at all electrodes. The power overhead is about 20% of the stimulation power.

8.2 A Fully Integrated Digital Hearing-Aid Chip with Human-Factors Considerations **9:00 AM**

S. Kim, KAIST, Daejeon, Korea

A digital hearing-aid chip integrates a pre-fitting verification algorithm to obtain gain fitting in two steps: coarse and fine. The internal ear canal modeling filter circuit enables the coarse fitting based on the shape of the external ear. Fine fitting verification is performed with external inputs. The $3.74mm^2$ chip draws less than 120μA from a single 0.9V supply in a 0.18μm CMOS technology.

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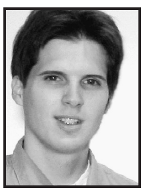
8.3 A Non-Coherent PSK Receiver with Interference-Canceling for Transcutaneous Neural Implants **9:30 AM**

M. Zhou, University of California, Santa Cruz, CA

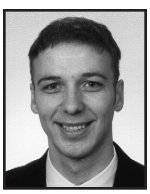
A PSK receiver uses bandpass sampling and thus avoids PLLs. It demonstrates that 2Mb/s data can be recovered with 20MHz carrier frequency in transcutaneous neural prostheses. The analog realization is able to cancel interference at 9dB larger than the signal without a filter. The demodulator is fabricated in 0.35μm CMOS, has an active die area of $2.6\times1.7mm^2$, and dissipates 6.2mW.



8.4 An 11k-Electrode 126-Channel High-Density Microelectrode Array to Interact with Electrogenic Cells **9:45 AM**

U. Frey, ETH, Zurich, Switzerland, [2]NewLogic, Lustenau, Austria

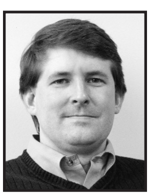
A microelectrode array allows an arbitrary group of 126 electrodes to be selected from a total of 11,016 in order to do cell or neural recordings from areas of interest with 18μm spatial resolution and 2.4μV input-referred noise. Signals are amplified by 0 to 80dB, bandpass filtered (0.3 to 4kHz), and finally digitized (20kS/s, 8b). Example recordings from acute brain slices are shown.



8.5 256-Channel Neural Recording Microsystem with On-Chip 3D Electrodes **10:15 AM**

R. Genov, University of Toronto, Toronto, Canada

A 16×16-channel $3.5\times4.5mm^2$ neural recording interface is fabricated in 0.35μm CMOS and is integrated with on-chip 3D Au and Pt microelectrodes. Each channel dissipates 15μW with an input-referred noise of 7μV over 5kHz bandwidth. A switched-capacitor delta read-out data-compression circuit trades recording accuracy for the output data rate. In-vitro experimental results validate the circuit design and the on-chip 3D electrode bonding technology.



8.6 A 2.2μW 94nV/√Hz Chopper-Stabilized Instrumentation Amplifier for EEG Detection in Chronic Implants **10:45 AM**

T. Denison, Medtronic, Columbia Heights, MN

A chopper-stabilized instrumentation amplifier is targeted for "deep-brain" human implants and consumes 2.2μW from a 1.8V supply. The integrated noise from 0.5 to 100Hz is 0.94μV, providing a noise efficiency factor of 4.9. The use of chopper stabilization provides rail-to-rail inputs and 105dB CMRR. An integrated 0.5Hz HPF is used to suppress electrode offsets. The circuit is also used in micropower bridge interfaces for impedance measurement and pressure sensing.

8.7 A Current-Sensitive Front-End Amplifier for Nano-Biosensors with a 2MHz BW11:15 AM

F. Gozzini, Politecnico di Milano, Milan, Italy

Active resistors up to 300GΩ operating down to the fA range are implemented in the feedback path of an integrator-differentiator transimpedance amplifier for high-sensitivity current measurements. The system has 4fA/√Hz noise up to 100kHz, a 2MHz bandwidth, and ensures unlimited measuring time even with nA DC input currents.

8.8 Miniaturization of Magnetic Resonance Microsystem Components for 3D Cell Imaging **11:30 AM**

L-S. Fan, National Tsing Hua University, Hsinchu, Taiwan

Magnetic resonance components, including gradient coils and RF coils, are miniaturized using a MEMS batch fabrication process and are combined with a 0.18μm CMOS RF transceiver front-end to implement a compact imaging system. The system aims for a resolution of $6\times6\mu m^2$ in a 120μm slice. The system could replace high-cost MRI counterparts for micron-resolution 3D images of live cells and enable a desktop cellular MRI system.

8.9 A High-Density Magnetoresistive Biosensor Array with Drift-Compensation Mechanism **11:45 AM**

S-J. Han, Stanford University, Stanford, CA

A DNA microarray of 1008 magnetoresistive sensors employing multidivided array structures for detecting either low concentration or large-scale gene information is integrated with a 0.25μm BiCMOS chip. The input-referred noise is below 55nV/√Hz. Ionic solution interferences and drifts during biological reaction are removed by applying an in-plane AC magnetic field with two DC field states. Parallel readout is realized by combining FDM with TDM.